## Incorporating Space into Our Economic Sphere of Influence Michael D. Griffin

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Good evening. Thank you for inviting me to speak tonight. It is not often that an aerospace engineer is invited to speak to an economic forum. However, I took a business degree along with my engineering and physics coursework, and I appreciate the economic impact that space has on our society, especially practical applications like communications, navigation, weather and remote sensing satellites as well as the economic, national security and scientific benefits. And this says nothing of the less-quantifiable benefits of intellectual inspiration.

Some of us gathered here tonight grew up during the Apollo era of the 1960s, NASA's apotheosis. We watched science fiction movies and television shows that made us believe that we – all of us and not simply a few astronauts – could become space travelers. Arthur C. Clarke's and Stanley Kubrik's masterpiece of science fiction "2001: A Space"

Odyssey" projected onto the screen of our collective human consciousness a future for us where, by now, hundreds of people would be living and working in space stations orbiting the Earth and outposts would exist on our moon. We would be journeying to other planets in our solar system, just as our European forbears came to America looking for new beginnings. This space age vision of our future proved illusory for our generation for two fundamental reasons: the limitations of our economic resources and the limitations of technology. Neil Armstrong's "giant leap for mankind" was not a journey that could be sustained without a more concerted investment of time, resources and energy than followed his seminal achievement on July 20, 1969.

But I believe that there are economic and technological reasons why we can now begin to afford and sustain this Vision for Space Exploration in a fashion where we "go-as-we-pay," and why the nations of the world making such investments of time, resources and energy will find that the benefits far outweigh the costs and risks involved. We have the technology and economic wherewithal to incorporate the benefits of space into our sphere of influence – to exploit the vantage point of space

and the space environment, and the natural resources of the moon, Mars, and near-Earth asteroids. Space exploration is not simply this century's greatest adventure; it is an imperative that, if not pursued with some concerted effort, will have catastrophic consequences for our society. I realize this is a bold statement, so allow me to explain.

On the day before he was assassinated in Dallas, President John F. Kennedy was in San Antonio, where he spoke about space exploration. He invoked Irish writer Frank O'Connor, who told the story of "how, as a boy, he and his friends would make their way across the countryside, and when they came to an orchard wall that seemed too high, and too doubtful to try, and too difficult to permit their voyage to continue, they took off their hats and tossed them over the wall – and then they had no choice but to follow them." The United States, the European Union, Russia, China, Japan, India, and others have tossed our caps over the wall of space exploration.

In that same speech, President Kennedy recited several technical advances from NASA's space program, explaining that "our effort in space is not, as some have suggested, a competitor for the natural

resources that we need to develop the Earth. It is a working partner and a co-producer of these resources." And he finished this speech with the recognition of the costs and risks involved with space exploration: "We will climb this wall with safety and with speed – and we shall then explore the wonders on the other side."

Even an emotionless engineer can be moved by President Kennedy's poetic framing of the issues of space exploration, but since this is an economic forum, let me now turn to the "dismal science." When President Kennedy spoke those words in 1963, the Gross Domestic Product of the United States was approximately \$2.8 trillion, in FY2000 dollars. In 2005 it was approximately \$11 trillion in those same FY2000 dollars -- four times larger. In 1963, the U.S. federal government spent approximately \$600 billion, again in FY2000 dollars, with NASA's allocation representing 2.3 percent of that amount. At the spending peak of the Apollo program, NASA represented 4.4 percent of the federal budget. Today, with a U.S. federal budget of almost \$2.5 trillion, NASA's budget represents about 0.6 percent of that.

Clearly our economy has grown, our society has changed, and our priorities for government spending have changed since 1963. Thus, in the latter half of the 1960s and early 1970s, our nation's leadership decided that we should not sustain such a high percentage of investment in the space program. In these years, the priorities of the U.S. federal budget changed to accommodate the escalating costs of the war in Vietnam, defense spending for the Cold War, and Great Society programs. Today, the costs of the Global War on Terrorism, Hurricane Katrina recovery, Social Security, and Medicare/Medicaid dominate our federal government spending. The costs of our nation's entitlement programs alone are projected to double in the next 10 years, from more than \$1 trillion per year today to more than \$2 trillion per year, as the baby boomers like me begin to retire. By comparison, NASA's budget of \$16.2 billion for this year is somewhere in the realm of what engineers call rounding error, at 0.6 percent of all federal spending.

Because of the magnitude of these changes over the last four decades, it is important to view our nation's investment in our civil space and aeronautics research program from this larger economic

perspective, because some critics have questioned the value proposition of even the current investment in NASA. I believe that we must recognize that the development of space is a strategic capability for our nations, and that we must bring the solar system into our economic sphere of influence. And equally, I believe that NASA must leverage the great economic engine of our nation and world. Thus, the companies and countries that many of you represent can take advantage of the trails we plan to blaze as we explore space, just as we leverage the capabilities you create.

As a U.S. federal agency, NASA expects only inflationary growth in our annual budget. Thus, we have adopted a "go-as-we-pay" approach for space exploration, science missions and aeronautics research. Thus, the primary pacing item for new ventures is our nation's ability to afford such capabilities.

Over the next three years, our highest priority is to complete assembly of the International Space Station and honor our agreements to our Russian, European, Japanese and Canadian partners in this venture. It will not be easy. The International Space Station is the world's

greatest engineering project, akin to such feats as the Great Wall of China, the pyramids of Egypt, the Panama and Suez canals, or the sea walls of Venice. Friends of mine who worked on the Apollo program have conveyed to me their belief that the construction of the International Space Station is just as tough a job.

There are many critics of this space station, just as there were critics of President Kennedy who called the Apollo program a "moondoggle." But I believe that the greatest achievement of the International Space Station partnership is the partnership itself, and that's a tough thing to criticize. For over six years, astronauts and cosmonauts have been living and working together onboard the space station. For the United States, the station is a national laboratory in space, where we will conduct research to make future exploration to other planets in our solar system possible. I hope this partnership will reap even greater dividends as we explore space together over many future generations. The unifying vision that forged this partnership during the 1990s, prompted by the Gore-Chernomyrdin Commission, is what we endeavor to carry forward today.

Our partnership has endured some hardships along the way, not least of which was the *Columbia* accident. I hope and believe that those hardships have built stronger bonds between us.

With the proper goals in mind, I believe the benefits of space exploration far outweigh the risks. Among the most practical of these is our work with hurricane-monitoring satellites, aircraft and sensors that allow meteorologists to track such storms and predict their severity and impact. Many people today do not even realize that their weather forecasts rely on information from space assets.

Broader misconceptions exist. NASA spinoff technologies were never Tang, Teflon or space pens. But while we actually can cite tens of thousands of legitimate technology spinoffs, including medical devices, fuel cells and batteries and even cordless tools, I would like to discuss a more seminal point. I want people to realize the key areas where NASA's space endeavors have created entirely new industrial capabilities that improve our fundamental way of life.

For example, NASA is one of the major consumers of liquid hydrogen to fuel our space shuttle and other rocket engines. Liquid

hydrogen is also used in the manufacturing of metals, glass, electronics and even foods. When you hear the term "hydrogenated fats" applied to baked goods like pastries and bread, it means that liquid hydrogen was one of the ingredients. NASA is such a large consumer of liquid hydrogen that after Hurricane Katrina, we returned several hundred thousand gallons to the nation's reserve and delayed several space shuttle rocket engine tests to alleviate a national shortage when our nation's liquid hydrogen production facilities and supply lines were disrupted. Likewise, we are a major consumer of liquid oxygen. Our huge demand market for these propellants sparked fundamental improvements in the production and handling of these volatile substances. Today, the ready availability of liquid oxygen allows firefighters, emergency response teams and nursing homes to carry on their backs or in suitcases portable, hand-carried oxygen tanks. In the 1960s, only select hospitals could supply oxygen, in hazardous oxygen tents.

I am sure that many of you would agree with me that the greatest revolution in our productivity and way of life has been the development

of the personal computer, internet and various handheld communication devices. Thirty-five years ago, engineers like me used three pieces of wood and a piece of plastic that moved – the slide rule – to make calculations. Thirty years ago, 1,000 transistors could fit on a silicon chip; today, it's 100 million. The cost of such chips has dropped by a factor of 100,000. Few people know that the development of the first microprocessors was born of a competition between Fairchild and Intel in the 1960s, to build components small enough to fit in NASA spacecraft. This straightforward NASA technical requirement spawned a whole new industry that grew in ways few, except perhaps Gordon Moore, could predict. Necessity is the mother of invention, and I believe that we are at our most creative when we embark on bold ventures like the space program.

So, with the economic growth and technology development we have seen since the 1960s, I believe that we are now entering a Renaissance period of space exploration where we can realize the vision that eluded us earlier. And as in the Renaissance, wealthy individuals will play a role in advancing the work of our architects, engineers and

technicians. These will be entrepreneurs who have made their wealth in other endeavors – Jeff Bezos from Amazon, Bob Bigelow from Budget Suites, Richard Branson from Virgin and Elon Musk of Paypal fame are examples. These gentlemen and others have put their personal time, resources and energy behind the notion that many more people can have personal experience in space than do so today. It is one thing to view pictures of Earth from the vantage point of space, even on an IMAX screen, but it is another thing entirely to see it with one's own eyes. Many friends of mine have spoken of the epiphany they experienced from this.

But let me be clear. NASA's job is *not* to sponsor space travel for private citizens. That is for private industry. My hope is the reverse; that when the public can purchase rides into space, NASA can leverage this capability. Likewise, I hope that one day NASA can leverage the expertise of companies not unlike FedEx or UPS today, to meet our cargo needs for the space station and future lunar outposts. And one day, maybe, astronauts onboard our *Orion* crew exploration vehicle on

their way to the moon and Mars can top off on liquid hydrogen from commercially available orbiting fuel stations.

In the process of building these new space capabilities, these entrepreneurs, along with NASA and other companies, are hiring more aerospace engineers. I believe that a key measure of a society's economic growth is the extent to which we are educating a technically literate people who can build the infrastructure to advance that society. It is deeply troubling to me when education statistics for the United States indicate there are more bachelor's degrees in psychology being awarded than engineering degrees. I am sure that even the economics majors here can appreciate my concern!

Again, NASA hopes to leverage, to the maximum extent possible, the capabilities that space entrepreneurs hope to create. A few years ago, when I was in the private sector working at InQTel, I helped fund a small software company seeking a better approach to visualizing satellite imagery. Over the years, that company grew into the backbone for Google Earth. Now, we hope to "spin-in" that capability to visualize imagery from other planets in our solar system, like the moon and Mars,

using data from various NASA satellites and the Mars rovers. By invoking such commercial capabilities, NASA can leverage the funding of other investors to our mutual benefit.

In conclusion, I would like to leave you with a final thought as to what might happen if we do not explore space, if we do not follow the cap we tossed over the wall in the 1960s. Last month in the journal *Science*, researchers examining the primordial material returned by NASA's *Stardust* space probe found that some of that material could not have come from the Kuiper Belt in the outer reaches of our solar system, but instead could only have come from our sun's core. Some of that material was even older than our own sun.

The history of life on Earth is the history of extinction events, with evidence for some five major such events in the history of the Earth.

The last of these occurred approximately 65 million years ago, when the dinosaurs that dominated the Earth for over 160 million years suffered a catastrophic extinction. It is believed that this event was caused by a giant asteroid which struck Earth in the Gulf of Mexico, triggering tsunamis, tectonic shifts and radically changing Earth's climate.

The brief history of humans is next to nothing compared to the history of other life on Earth, and even less so compared to the age of our solar system or of the universe. Our species hasn't been around long enough to have experienced a cataclysmic extinction event. But they will occur, whether we are ready for them or not.

In the end, space exploration is fundamentally about the survival of the species, about ensuring better odds for our survival through the promulgation of the human species. But as we do it, we will also ensure the prosperity of our species in the economic sense, in a thousand ways. Some of these we can foresee, and some we cannot. Who could claim that he or she would have envisioned the Boeing 777, after seeing the first Wright Flyer? And yet one followed the other in the blink of an historical eye.

For this and many other economic and scientific reasons, we must explore what is on the other side of that wall, walk in the footprints of Neil Armstrong, and make that next giant leap for mankind.

Thank you.